

# AN ELECTROPOLISH/GRINDING MEANS FOR AN INNER SURFACE OF A LONG TUBE

## 1. Field of the Invention

[0001] The present invention is an electropolish/grinding means for an inner surface of a long tube, especially applied to a long tube of greater than 3 meters long and a diameter range under 5 cm.

## 2. Background of the Invention

[0002] A process of electropolish is to connect a workpiece to an anode and a metal to a cathode, aforesaid whole structure of workpiece connecting to anode and metal connecting to cathode are put into electrolyte for electrifying direct current, thus defects on workpiece surface are removed and the surface is then shining and smooth. Features of electropolish are that improving surface cleanness, roughness, passivation, etc. For different fields of semiconductor, chemical industry, biochemical engineering, foodstuff industry, needed tubes of aforesaid fields are to deliver fluids of those fields, and inner surfaces of tubes are treated by polish or electrolysis to approach high cleanness and anti-corrosion. Especially, products of IC/LCD/III-V require high standards of cleanness and anti-corrosion, thus, applying the present invention to said products are a challenge.

[0003] In prior arts of US Patent No. 4826582 and 4849084, which are figuring out part of the technologies of electropolish a 10-meter heat exchange tube, and an electrode device for positioning workpiece and sealing electrolyte is a must. The prior arts adopt a 3-layer structure of delivering electrolyte of high pressure air, but unfortunately said structure is very complicate and only suitable for bigger diameter workpieces, not for diameters under 3 cm.

[0004] In prior art of US Patent Number 5958195, which is the technology of electrolyzing and polishing an inner surface of a long and bended tube. However, to electrolyze and polish a bended tube, electrode

must move alone bended curve for not happening short circuit. The most important parts are a flexible electrode and an insulation device. The insulation device is to avoid short circuit and non-concentricity, but it blocks electrolyte flowing and makes un-average electric field, etc.

5 [0005] In prior arts of US Patent Number 4601802 and 4705611, which offer a fixture applied an inside tube, and the fixture stabilizes a plurality of axially rotating tubes simultaneously. An end connector can circulate tube and exhaust gas from an upper end, and electrolyte can be recycled after overflowing. An electrode length is equal to the tube's length, therefore a huge  
10 space and a super power supplier are needed to fit such conditions.

[0006] Based on the aforesaid issues, the present inventor of the patent has being studied and referred to practical experiences and theory for designing and effectively improving the prior arts.

### Summary of the Invention

15 [0007] The first object is to offer an electropolishing/grinding means for an inner surface of a long tube, which improves an electrode design and applies a theory of huge and fine polishing to a same electrode means for improving a successful rate in manufacturing and an electropolish surface and passivation effect.  
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[0008] The second object is to offer an electropolishing/grinding means for an inner surface of a long tube, which can electrolyze and polish an inner surface of a tube greater than 3 meters and diameter range under 5 cm; a structure of the means is simple to save an equipment cost.

25 [0009] The third object is to offer an electropolishing/grinding means for an inner surface of a long tube, which avoids short circuit and non-concentricity problems. An electrode of the present invention is installed through a center of a partition, so the electrode has a certain distance with the inner surface in tube because the partition supports electrode. Therefore, the  
30 short circuit and non-concentricity are solved; further, the average electric field is kept all the time because of the partition is round.

[0010] The fourth object is to offer an electropolishing/grinding means

for an inner surface of a long tube, which electrode can be designed as multi-section, to do so figures out that needing a huge space to store such similar equipment; further, the electrode can be added to different sections depending on needs to improve electropolish result.

- 5 [0011] The appended drawings will provide further illustration of the present invention, together with description; serve to explain the principles of the invention.

### **Brief Description of the Drawings**

- 10 [0012] Figure 1 is a scheme of a practical application of the present invention.

[0013] Figure 2 is a first preferred embodiment of the present invention.

[0014] Figure 3 is a preferred embodiment of a partition of the present invention.

- 15 [0015] Figure 4 is a scheme of a practical application of the present invention.

[0016] Figure 5 is a partial enlarged view of a preferred embodiment of a long tube of the present invention.

- 20 [0017] Figure 6 is a sectional view of a preferred embodiment of the partition of the present invention.

[0018] Figure 7 is a preferred embodiment of the long tube of the present invention.

### **Detailed Description of the Present Invention**

- 25 [0019] For different fields of semiconductor, chemical industry, biochemical engineering, foodstuff industry, inner surfaces of needed tubes of aforesaid fields are treated by electrolyzing and polishing for improving surface cleanness, roughness and passivation results. The present invention comprises an electrolyte delivering system, which makes electrolyte averagely

pass through an inner surface of a long tube; a cable, which guides direct current to a working area of an inner surface of tube, and electrolyte is an electrifying media to make a complete electric path, wherein a magnetic-levitated device can be added on, which drives electrode axial motion and revolving motion, further to avoid a contact of a negative electrode and the positive inner surface. Plural places of radial top of the partition are installed some abrasive blocks as  $Al_2O_3$ , etc., and the abrasive blocks cooperates with plural closed fillisters, springs and thimbles for constantly keeping the abrasive blocks onto the inner surface, results of grinding and electropolishing are then achieved.

[0020] Referring to figure 1, which is a scheme of a practical application of the present invention. Electrolyte is stored in a tank 10. There is a heater 11 in the tank 10 to keep warming and heating the electrolyte. Electrolyte passes through a switch 12 and a pipe 23 to a tube 16, wherein the switch 12 is made of Teflon or other heat-resistant and acid-proof materials. The tube 16 is placed on an inclined platform 17, and thus a higher end of tube 16 connects to the pipe 23 for electrolyte passing from higher end to a lower end. Inclined angles of the inclined platform 17 can be adjusted to control electrolyte flowing speeds. Tube 16 has an electropolishing device inside, which connects to a first power device 29 via a cable 20,20; the first power device 29 supplies direct current for electropolishing reaction. The present invention adopts that electron exchanging from an anode half reaction and a cathode half reaction to generate an electropolishing result. Tube 16 is anode, thus an inner surface of tube 16 is anode, and anode loses electrons; the electrode is cathode, and cathode receives electrons; figure 1 does not show the electrode, so only cable 20 is shown up to represent above connection relationship. Tube 16 is about 2 meters long or more than that, so electrolyte temperature is lower when electrolytes approaching to a lowest end of tube 16, thus plural halogen bulbs 15 are placed around tube 16 for heating. Electrolyte is recycled after passing through tube 16 to a recycling tank 13, then it is delivered back to tank 10 by a pump 14 with heat-resistant and acid-proof. A driving apparatus 27 is set surround tube 16 and has several outer electromagnets inside (not shown in figure); when the outer electromagnets cooperating with a second power device 30, generating electromagnetic to associate with plural fixed magnets for revolving the fixed magnets, thus the electropolishing device in tube 16 is in rotating motion. An axial driven mechanism 22 carries the driving

apparatus 27 and mounts on a guiding rod mechanism 31; Cooperation of the axial driven mechanism 22 and the guiding rod mechanism 31 is thus to move the driving apparatus 27 which parallel to the tube 16. For the embodiment, axial driven mechanism 22 moves from lower to higher when electropolishing reaction-being reaction is processed for exhausting air bulbs generated by reaction. As aforesaid, which is a complete process and will be described in detail as following.

[0021] Referring to figure 2, which is a first preferred embodiment of the present invention. The embodiment applies to polish an inner surface of the tube 16, which is longer than 3 meters and made of SUS300 series without polarization. The embodiment comprises a fixed magnet mechanism 28 including plural fixed magnets 281, which adopt axial longest sides of themselves for being combined and formed to become the fixed magnet mechanism 28; at least one electrode 21, which is made of copper and wolfram, an end of the electrode 21 is bounded a cable 20, which connects to a first power device 29 outside of the tube 16 for power supply; at least two partitions, which is made of Teflon or materials without electric conductivity for limiting electropolishing range, and it is to save power and enhancing electropolishing result. Please refer to figure 3, which is a preferred embodiment of a partition of the present invention, plural slots 25 are designed on an outer edge of partition, the slots make electrolyte flow close to inner surface more fluently, a boundary layer is then broken to generate an average anode membrane, thus air bulbs generated by electropolishing are exhausted fast; further, the partitions 18 and 26 has many holes as meshes for fluently introducing electrolyte, to avoid contact of negative electrode 21 and positive inner surface and figure out non-average polishing of eccentric electrode, dimensions of the partitions cannot be enlarged, the present invention takes the driving apparatus 27 and the fixed magnet mechanism 28 to form a magnetic levitation effect, which means using magnetic repulsiveness and magnetic attraction to keep away from the partitions and inner surface and avoid the eccentric situation, the first partition 18 is on an electrode 21 end opposite another end connecting to the cable 20, the second partition 26 is placed on another end of the electrode 21, thus the two ends of the fixed magnet mechanism 28 are individually the first partition 18 and the second partition 26; further, the fixed magnet mechanism 28 is radially and averagely distributed on the two partitions, a surface of the second partition 26

connecting to the fixed magnet mechanism 28 which opposite side is installed a propeller mechanism, and the propeller mechanism can be a propeller or as shown in figure 7, which is a preferred embodiment of the long tube of the present invention, which means a screw slideway 24, and it is to fast remove  
5 air bulbs generated from electropolishing reaction; the driving apparatus 27, which comprises plural outer electromagnets 271 distributed around the tube 16, and relative position in the tube 16 is fixed magnet mechanism 28, which connects to the second power device 30 for supplying power to outer electromagnets 271; and the axial driven mechanism 22, which carries both  
10 the driving apparatus 27 and the second power device 30 for axially moving aforesaid apparatus and device, the moving speed is from 5 to 20 cm/min. Electrode 21, two partitions 18 and 26 and fixed magnet mechanism 28 are in tube 16, and they cooperate with driving apparatus 27, thus, electromagnet force is going to drive fixed magnets 281 in fixed magnet mechanism 28,  
15 therefore electrode 21, two partitions 18 and 26 and fixed magnet mechanism 28 are rotated along their same axis; axial driven mechanism 22 simultaneously drives driving apparatus 27 and second power device 30, and the present invention also moves parallel to the axis; finally when electrode 21 connects to first power device 29, a complete electropolishing reaction in a  
20 long tube is done.

[0022] As mentioned above, driving apparatus 27 is an electromagnet apparatus, when driving apparatus 27 connects to second power device 30, plural outer electromagnets 271 are then driven, and plural fixed magnets 281 in fixed magnet mechanism 28 are in rotation as well, which rotation speed is  
25 10 to 200 rpm; on the other hand, driving apparatus 27 is a rotational mechanism, when driving apparatus 27 connects to second power device 30, plural outer electromagnets 271 in driving apparatus 27 are driven via direct mechanical transmission, and plural fixed magnets 281 in fixed magnet mechanism 28 are in rotation as well.

[0023] Please refer to figure 4, which is a scheme of a practical application of the present invention and a preferred embodiment of electropolishing of the present invention. The embodiment is that placing the electrode on a front place, and a front end of electrode is bounded by cable 20, which connects to first power device 29; when electropolishing action is in  
30 moving, axial driven mechanism 22 is also in move from higher to lower for  
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exhausting particles generated by polishing.

[0024] Referring to figure 5, which is a partial enlarged view of a preferred embodiment of a long tube of the present invention, which is applied to the inner surface of tube 16 full of electrolyte, and tube 16 is made of SUS300 series without polarization and longer than 3 meters, and comprising: the fixed magnet mechanism 28, including plural fixed magnets 281, which adopt axial longest sides of themselves for being combined and formed to become the fixed magnet mechanism 28; at least one electrode 21, which is made of copper and wolfram, an end of the electrode 21 is bounded a cable 20, which connects to the first power device 29 outside of the tube 16 for power supply; at least two partitions, which is made of Teflon or materials without electric conductivity for limiting electropolishing range, and it is to save power and enhancing electropolishing result. Please refer to figure 3, which is a preferred embodiment of a partition of the present invention, plural slots 25 are designed on an outer edge of the first partition 18, the slots 25 make electrolyte flow close to inner surface more fluently, a boundary layer is then broken to generate an average anode membrane, thus air bulbs generated by electropolishing are exhausted fast; further as shown in figure 3, the partitions 18 and 26 has many holes 34 as meshes for fluently introducing electrolyte, to avoid contact of negative electrode 21 and positive inner surface and figure out non-average polishing of eccentric electrode, dimensions of the partition 18 cannot be enlarged, the present invention takes the driving apparatus 27 (not shown in figure 5) and the fixed magnet mechanism 28 to form a magnetic levitation effect, which means using magnetic repulsiveness and magnetic attraction to keep away from the partitions and inner surface and avoid the eccentric situation, the first partition 18 is on an electrode 21 end opposite another end connecting to the cable 20, the second partition 26 is placed on another end of the electrode 21, thus the two ends of the fixed magnet mechanism 28 are individually the first partition 18 and the second partition 26; further, the fixed magnet mechanism 28 is radially and averagely distributed on the two partitions; referring to figure 6, which is a sectional view of a preferred embodiment of the partition of the present invention, there are plural closed fillisters placed on radial end of the second partition 26, and each of the closed fillister has a spring 33 and a thimble 35. The thimble 35 protrudes outside the radial end and supports an abrasive 32 made of  $Al_2O_3$ , and the abrasive 32 continuously supports the inner surface of tube for

grinding. Following components of the present embodiment can be same as figure 2, which comprises driving apparatus 27, including plural outer electromagnets 271 distributed around the tube 16, and relative position in the tube 16 is fixed magnet mechanism 28, which connects to the second power device 30 for supplying power to outer electromagnets 271; and the axial driven mechanism 22, which carries both the driving apparatus 27 and the second power device 30 for axially moving aforesaid apparatus and device, the moving speed is from 5 to 20 cm/min. Electrode 21, two partitions 18 and 26 and fixed magnet mechanism 28 are in tube 16, and they cooperate with driving apparatus 27, thus, electromagnet force is going to drive fixed magnets 281 in fixed magnet mechanism 28, therefore electrode 21, two partitions 18 and 26 and fixed magnet mechanism 28 are rotated along their same axis; axial driven mechanism 22 simultaneously drives driving apparatus 27 and second power device 30, and the present invention also moves parallel to the axis; finally when electrode 21 connects to first power device 29, a complete electropolishing reaction in a long tube is done.

[0025] As mentioned above, driving apparatus 27 is an electromagnet apparatus, when driving apparatus 27 connects to second power device 30, plural outer electromagnets 271 are then driven, and plural fixed magnets 281 in fixed magnet mechanism 28 are in rotation as well, which rotation speed is 10 to 200 rpm; on the other hand, driving apparatus 27 is a rotational mechanism, when driving apparatus 27 connects to second power device 30, plural outer electromagnets 271 in driving apparatus 27 are driven via direct mechanical transmission, and plural fixed magnets 281 in fixed magnet mechanism 28 are in rotation as well.

[0026] While the present invention has been shown and described with reference to preferred embodiments thereof, and in terms of the illustrative drawings, it should be not considered as limited thereby. Thus, the present invention is infinitely used. However, various possible modification, omission, and alterations could be conceived of by one skilled in the art to the form and the content of any particular embodiment, without departing from the scope and the spirit of the present invention.

[0027] The invention is disclosed and is intended to be limited only the scope of the appended claims and its equivalent area.